

A satellite image of a hurricane, showing a well-defined eye and spiral cloud bands, serves as the background for the slide.

# **Socio-Economic Research on Hurricane Forecasts and Warnings: A Discussion of Results and Research Plans**

Jeff Lazo  
Rebecca Morss  
Julie Demuth

Societal Impacts Program  
National Center for Atmospheric Research

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# Overview

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**Hurricane Forecast Socio-Economic Working Group**

**Benefits of Improved Hurricane Forecasting**

**Current Research**

- **Hurricane Forecast Improvement Project**
- **Communicating Hurricane Information**
- **Warning Decisions: Extreme Weather Events**

# Hurricane Forecast Socio-Economic Working Group

## NATURAL HAZARDS REVIEW

VOLUME 8 / NUMBER 3

AUGUST 2007

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- 43 Social Science Research Needs for the Hurricane Forecast and Warning System: An Introduction  
*Jeffrey K. Lazo and Walter Gillis Peacock*

### Technical Papers

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*H. E. Willoughby, E. N. Rappaport, and F. D. Marks*
- 50 Organizational Communication and Decision Making for Hurricane Emergencies  
*Michael K. Lindell, Carla S. Prater, and Walter Gillis Peacock*
- 61 Social Science Research Needs: Focus on Vulnerable Populations, Forecasting, and Warnings  
*Brenda D. Phillips and Betty Hearn Morrow*
- 69 Evacuation Decision Making and Behavioral Responses: Individual and Household  
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*David Letson, Daniel S. Sutter, and Jeffrey K. Lazo*
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IN BOX  
INSIGHTS and INNOVATIONS

## Social Science Research Needs for the Hurricane Forecast and Warning System

BY HUGH GLADWIN, JEFFREY K. LAZO, BETTY HEARN MORROW,  
WALTER GILLIS PEACOCK, AND HUGH E. WILLOUGHBY

### THE IMPORTANCE OF SOCIAL SCIENCE RESEARCH.

The 2004 and 2005 hurricane seasons awoke the United States to the potential societal impacts of landfalling Atlantic hurricanes. The toll was greater than \$175 billion in damage and about 5,400 deaths throughout the Atlantic Basin. While 2006 and 2007 were quieter, climatologists believe that we are still in a period of increased hurricane activity. Given that crucial hurricane forecasts, especially those for Katrina, were accurate and timely, it is necessary to understand why many people did not or were not able to heed those warnings. In this sense, hurricane disasters are "social constructs"—as much or more manmade than "natural" disasters. Over the last decade, there has been a growing recognition that social and behavioral research is essential to understanding the causes of high societal-impact weather-related disasters. As stated in Pielke and Kimpel's *Societal Impacts of Weather* report, "It is generally accepted that weather problems are both social and physical phenomena. Research findings from the social sciences have been crucially important in understanding and improving human responses to economic, social, and environmental weather-related risks. Despite the centrality of this research area, it has in the past received too little attention and resources." Pressing meteorological, technological, and social issues that drive the need

for social science research on forecasts and warnings include: changes and improvements in forecast products; changes in ways to create, manipulate, and disseminate information; increased recognition of hurricane impacts as social phenomena; increasing and increasingly diverse population and assets in harm's way; availability of new social science tools, methods, and paradigms; and institutional requirements to evaluate, justify, and develop guidance for programs and future practices.

Based on a 2005 workshop in Pomona, California; 2004 and 2005 Natural Hazards workshop sessions held in Boulder, Colorado; a series of white papers; and additional input from the broader social science research community, the August 2007 special issue of *Natural Hazards Review (NHR)* contains a series of papers on societal aspects of the hurricane forecast and warning system, written to identify gaps in understanding and needs for social science research. As Gladwin et al. stated in *NHR*, "Expected results from this effort are (1) a focused applied research agenda designed to generate short-term immediate benefits; (2) a broader, more basic research agenda addressing fundamental theoretical and exploratory research designed to generate long-term improvements; (3) methods to enable the social science research community to gather and further develop research priorities and future agendas; and (4) a concept for a long-term, multidisciplinary, institutional approach to undertaking identified research priorities."

**SCIENCE ISSUES.** At least three cross-cutting issues necessitate innovative social science investigations. First, as was never more apparent than in the case of Hurricane Katrina, vulnerable populations require particular consideration. Many people lack economic and/or human resources to respond appropriately. Circumstances and response options of vulnerable populations must be recognized and understood to develop appropriate warning products and policies to prevent

**AFFILIATIONS:** GLADWIN AND WILLOUGHBY—Florida International University, Miami, Florida; LAZO—National Center for Atmospheric Research, Boulder, Colorado; MORROW—Consulting Sociologist, Miami, Florida; PEACOCK—Texas A&M University, College Station, Texas  
**CORRESPONDING AUTHOR:** Jeff Lazo, NCAR, Box 3000, Boulder, CO 80307  
E-mail: lazo@ucar.edu

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# Benefits of Improved Hurricane Forecasting

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- *What is the value to households of potentially improved hurricane forecasts?*
- **Stated-preference method**
  - Stated Choice (conjoint analysis)
- **Implementation – Betty Morrow**
  - Miami, FL – September 4, 2008
  - 80 subjects



# Benefits of Improved Hurricane Forecasting

- **Survey Outline**
  1. personal impact / vulnerability
  2. perceived risk
  3. preparation for hurricane
  4. evacuation decisionmaking
  5. likely impact on household
  6. hurricane forecasts
    - attributes
    - perceived accuracy
  7. improved hurricane forecasts
    - attributes
    - choice sets
  8. current hurricane forecasts
  9. socio-demographics

Version 1 - Subject \_\_\_\_\_ Time \_\_\_\_\_

## HURRICANES AND YOU



Hurricane Ivan - September 16, 2004

ANY PERSONAL INFORMATION COLLECTED IS CONFIDENTIAL AND IS ONLY USED TO  
GROUP YOUR ANSWERS WITH OTHERS OF SIMILAR BACKGROUND.

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Please indicate which Program, if you had to choose, you would prefer.

	Accuracy of Current Forecasts	Program C ▼	Program D ▼
Time of expected landfall	Now accurate to within 8 hours	4 hours	No change
Maximum wind speed	Now accurate to within 20 miles per hour	No change	15 hours
Projected landfall	Now accurate to within 100 miles	80 miles	65 miles
Expected storm surge	Now accurate to within 8 feet above sea level	4 feet	No change
Increase in Annual Cost to Your Household		\$12 per year	\$24 per year
I would prefer (please put check mark in box indicating your preferred Program)		Program C <input type="checkbox"/>	Program D <input type="checkbox"/>

35

Would you prefer to keep forecast quality the way it is now and pay no more in taxes or stay with the Program you indicated above?

<input type="checkbox"/>	Keep forecast quality the way it is now and pay no more in taxes.
<input type="checkbox"/>	Undertake the Program chosen above and pay the amount indicated.

# Choice Set Attributes and Levels

Level	Time of expected landfall	Maximum wind speed	Projected location of landfall	Expected storm surge	Increase in Annual Cost to Your Household
Currently accurate to within (baseline)	8 hours 48 hours in advance	20 miles per hour 48 hours in advance	100 miles 48 hours in advance	plus or minus 8 feet of height above sea level 48 hours in advance	\$12
Intermediate Improvement	6 hours	15 miles per hour	80 miles 48 hours in advance	6 feet of height above sea level	\$24
Maximum Improvement	4 hours	10 miles per hour	65 miles 48 hours in advance	4 feet of height above sea level	\$48

# Program C

	Time of expected landfall	Maximum wind speed	Projected location of landfall	Expected storm surge	Increase in Annual Cost to Your Household
		20 miles per hour 48 hours in advance			\$12
			80 miles 48 hours in advance		
	4 hours			4 feet of height above sea level	



# Program D

	Time of expected landfall	Maximum wind speed	Projected location of landfall	Expected storm surge	Increase in Annual Cost to Your Household
	8 hours 48 hours in advance			plus or minus 8 feet of height above sea level 48 hours in advance	
		15 miles per hour			\$24
			65 miles 48 hours in advance		

34

Please indicate which Program, if you had to choose, you would prefer.

	Accuracy of Current Forecasts	Program C ▼	Program D ▼
Time of expected landfall	Now accurate to within 8 hours	4 hours	No change
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# Benefits of Improved Hurricane Forecasting

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- Econometric modeling and analysis – Don Waldman
  - random utility behavioral model

$$U_{ij} = \beta' x_{ij} + \varepsilon_{ij}, \quad i = A, B; j = 1, \dots, 8,$$

- parameter estimates represent marginal utilities
  - landfall time, windspeed, location, storm surge
  - cost (*marginal utility of income*)
- estimation is by bivariate probit
  - first choice between A and B
  - second choice between A/B and “do nothing”
- analyzed only choice occasions 2 – 8
- 80 subjects – 7 choices each = 560 “observations”
  - quadrature to account for intra-subject correlation

# **Modeling Results**

## **Choice Sets 2-8 Only (n = 560)**

### **Bivariate Probit w/quadrature**

	<b>Est.</b>	<b>t-ratio</b>	<b>Marginal WTP</b>
<b>Landfall Time</b>	<b>-0.067</b>	<b>-3.57</b>	<b>\$2.18</b>
<b>Maximum wind speed</b>	<b>-0.008</b>	<b>-1.08</b>	<b>\$0.26</b>
<b>Landfall location</b>	<b>-0.007</b>	<b>-3.22</b>	<b>\$0.23</b>
<b>Storm surge</b>	<b>-0.062</b>	<b>-3.50</b>	<b>\$2.04</b>
<b>Annual Cost</b>	<b>-0.030</b>	<b>-11.27</b>	

# WTP Calculation: Improve Baseline to Intermediate on All Attributes

Attribute	Baseline (all 48 hours in advance)	Intermediate Improvement	Diff.	Marg. WTP	WTP
Time of expected landfall	± 8 hours	± 6 hours	2	\$2.18	\$4.36
Maximum wind speed	± 20 mph	± 15 mph	5	\$0.26	\$1.30
Projected location of landfall	± 100 miles	± 80 miles	20	\$0.23	\$4.60
Expected storm surge	±8' of height above sea level	± 6' of height above sea level	2	\$2.04	\$4.08
Total WTP					\$14.34



# Current Research

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- 1. Hurricane Forecast Improvement Project**
- 2. Communicating Hurricane Information**
- 3. Hurricane and Flood Warning Decisions**

# Hurricane Forecast Improvement Project

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- **Socio-Economic Impacts Assessment**
  - **Assessment of Emergency Managers - Betty Morrow**
    - in-depth focused interviews
    - emergency managers
    - stakeholder communities (hospitals / transportation / etc)
  - **Household valuation – Jeff Lazo**
    - non-market stated choice assessment
    - adapted *Benefits of Improved Hurricane Forecasting*
    - attribute set from HFIP
    - 400 sample across the vulnerable region

# Communicating Hurricane Information

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- **Examining the Hurricane Warning System: Content, Channels, and Comprehension**
  - NSF-NOAA joint announcement of opportunity
  - 18-24 month project
- **Research foci**
  - How are hurricane forecast and warning messages developed and communicated by NWS forecasters, emergency managers, broadcast meteorologists, and the public?
  - How do at-risk coastal residents, including more vulnerable populations, comprehend and react to specific components of warning messages?

## Official Forecast

NWS  
Forecasters --  
NHC, WFOs

## Intermediate Channels

Broadcast  
Meteorologists

Emergency  
Managers

## End Users

General  
Public

- survey
- vulnerable population
- focus groups
- laboratory study

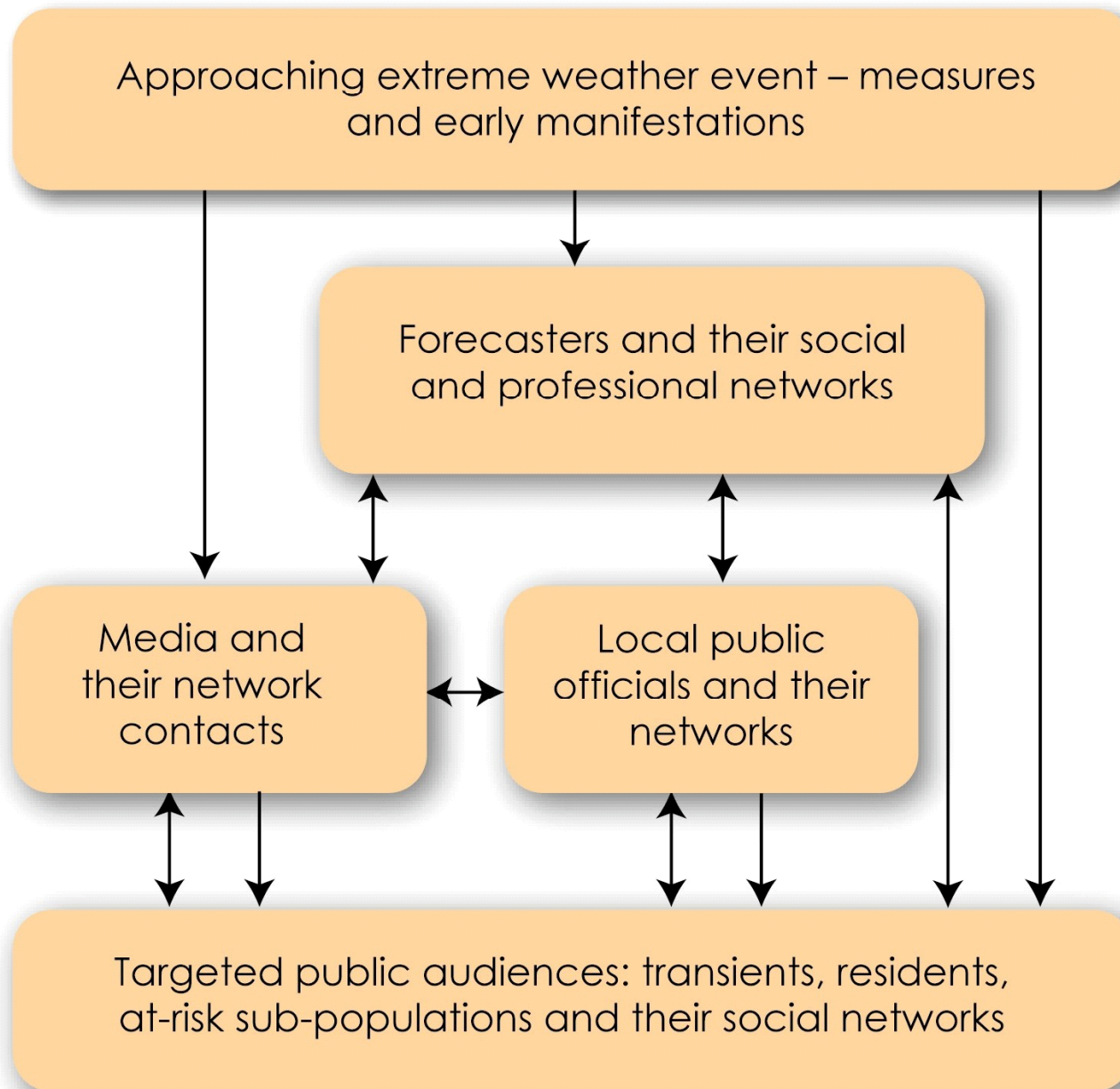


# Hurricane and Flood Warning Decisions

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- **Warning Decisions in Extreme Weather Events: An Integrated Multi-Method Approach**
  - Funding from NSF Human and Social Dynamics program
  - 3 year project
- **Parallel studies**
  - Flash floods in Boulder, Colorado
  - Hurricanes in Miami, Florida





Researchers	Advisors
<p><b>Ann Bostrom</b> – <i>Risk Communication</i></p> <p><b>Julie Demuth</b> – <i>Meteorology / Communication</i></p> <p><b>Gina Eosco</b> – <i>Communication</i></p> <p><b>Somer Erickson</b> – <i>Emergency Management</i></p> <p><b>Brandi Gilbert</b> – <i>Sociology</i></p> <p><b>Hugh Gladwin</b> – <i>Sociology</i></p> <p><b>Matthew Jensen</b> – <i>Mgmt. Information Systems</i></p> <p><b>Jeff Lazo</b> – <i>Economics</i></p> <p><b>Claude Miller</b> – <i>Communication</i></p> <p><b>Betty Morrow</b> – <i>Sociology</i></p> <p><b>Rebecca Morss</b> – <i>Meteorology</i></p> <p><b>Dan O’Hair</b> – <i>Communication</i></p> <p><b>Kathleen Tierney</b> – <i>Sociology</i></p> <p><b>Jennifer Thacher</b> – <i>Economics</i></p> <p><b>Don Waldman</b> – <i>Economics</i></p>	<p><b>David Bernard</b></p> <p><b>Frank Billingsley</b></p> <p><b>Luis Carrera</b></p> <p><b>Christopher Davis</b></p> <p><b>Mark DeMaria</b></p> <p><b>Kelvin Droegemeier</b></p> <p><b>Gene Hafele</b></p> <p><b>Tim Heller</b></p> <p><b>Greg Holland</b></p> <p><b>Chuck Lanza</b></p> <p><b>Max Mayfield</b></p> <p><b>Bryan Norcross</b></p> <p><b>Frank Redding</b></p> <p><b>Jamie Rhome</b></p>





# Thank You!

Jeff Lazo – [lazo@ucar.edu](mailto:lazo@ucar.edu)

Rebecca Morss – [morss@ucar.edu](mailto:morss@ucar.edu)

Julie Demuth – [jdemuth@ucar.edu](mailto:jdemuth@ucar.edu)

[www.sip.ucar.edu](http://www.sip.ucar.edu)